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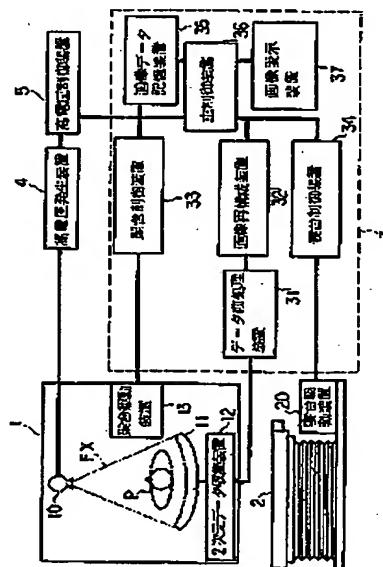
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(54)【発明の名称】 コンピュータ断層撮影装置

(57)【要約】

【目的】本発明の目的は、２次元アレイ検出器を用いたヘリカルスキャン方式のＣＴで、簡易な処理でアーチファクトの少ない再構成画像を作成可能なＣＴを提供することである。

【構成】本発明は、２次元アレイ検出器１１を用いてヘリカルスキャンにより投影データを収集するコンピュータ増倍撮影装置において、実際に得られた２次元状の投影データから任意に定めた仮想平面の位置に近似する×線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。



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【特許請求の範囲】

【請求項 1】 2次元アレキ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、実際に得られた2次元状の投影データから任意に定めた仮想平面の位置に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とするコンピュータ断層撮影装置。

【請求項 2】 前記近似投影データを同時に収集されたスライス方向に隣接する少なくとも2つの実際に得られた投影データの補間により求めることを特徴とする請求項 1記載のコンピュータ断層撮影装置。

【請求項 3】 前記仮想平面は前記ヘリカルスキャンの中心軸に対して傾斜する斜断面として設定されることを特徴とする請求項 1記載のコンピュータ断層撮影装置。

【請求項 4】 前記仮想平面を空間的に連続するように複数設定し、各仮想平面について再構成像を再構成することによりボリュームデータを得ることを特徴とする請求項 1記載のコンピュータ断層撮影装置。

【請求項 5】 前記ヘリカルスキャンはX線源が被検体に対して相対的に螺旋軌道上を移動することにより実行され、前記仮想平面を前記X線源が略180度回転する間の複数のX線バスにより描かれる湾曲面に近似する平面として設定されることを特徴とする請求項 1記載のコンピュータ断層撮影装置。

【請求項 6】 前記仮想平面を、半螺旋の各回転角における前記X線源の2座標と、前記X線源の螺旋軌道により規定される円筒と前記仮想平面とが交差する楕円の2座標との差の絶対値の最大値が、最小になるように設定することを特徴とする請求項 5記載のコンピュータ断層撮影装置。

【請求項 7】 前記仮想平面を、半螺旋の各回転角における前記X線源の2座標と、前記X線源の螺旋軌道により規定される円筒と前記仮想平面とが交差する楕円の2座標との差の二乗平均誤差が、最小になるように設定することを特徴とする請求項 5記載のコンピュータ断層撮影装置。

【請求項 8】 前記近似投影データは、前記X線源とF O V中心との距離を直径とする円筒と、前記仮想平面の交差する楕円上を通過するX線バス上のデータであることを特徴とする請求項 5記載のコンピュータ断層撮影装置。

【請求項 9】 前記近似投影データは、前記X線源を中心にしてF O V中心を通る円筒と前記仮想平面の交わる楕円を通過するX線バス上のデータであることを特徴とする請求項 5記載のコンピュータ断層撮影装置。

【請求項 10】 前記2次元アレキ検出器のスライス方向の幅から換算したF O V中心でスライス方向の再構成厚みをcとしたとき、前記X線源の1回転での被検体の相対的移動距離を略1.5cに設定することを特徴とする

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る請求項 5記載のコンピュータ断層撮影装置。

【請求項 11】 前記再構成は部分角再構成法を利用したものであることを特徴とする請求項 1記載のコンピュータ断層撮影装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、ヘリカルスキャン方式のコンピュータ断層撮影装置（以下「CT」と略す）に関する。

【0002】

【従来の技術】現在、被検体を透過したX線を検出する検出器を1次元に配列した1次元検出器を持つCTが一般的に普及している。そして、近年では、X線源（ソース）と検出器を連続回転させながら複合を移動させることで、複合と共に移動する移動座標系においてX線源が螺旋軌道を描いて移動するいわゆるヘリカルスキャン方式が急速に普及し始めている。さらに、1次元検出器の多列化や照射X線のコーンビーム化により、データの3次元化の実現性が模索されている。

【0003】1次元検出器によるヘリカルスキャン方式では、X線源が螺旋軌道を移動するため、再構成断面上の投影データの大部分を線形補間処理等により近似的に補間作成することが必要である。この作成したデータを、以下、近似投影データと称する。再構成は実質的に1回転分のデータが必要になるので、例えば10cm分の厚みを持つ領域を2mmスライスデータとして欲しければ、50回転のスキニングが必要であった。

【0004】1次元検出器を2列設けたいわゆるデュアルスライス・ヘリカル方式は、データ収集速度が原理的に上記方式の2倍になる。これを発展させて1次元検出器を多列化することが考えられるが、列間でのX線バスが平行とは見做せなくなる。仮にこれを平行とみなして、単純に列毎に画像をマルチスライスとして再構成したのではアーチファクトの多い実用に耐えない画像となってしまう。これらの問題を克服する技術は現在提案されておらず、従ってこの方式では倍々2倍の高速化が限度であると結論されている。

【0005】コーンビームスキニング方式では、被検体がコーンビーム内に完全に含まれる場合には理論的に完全な再構成が可能であるが、被検体がコーンビーム内に完全に含まれない場合には、適当な再構成の解法が提案されていない。

【0006】

【発明が解決しようとする課題】以上のように、2次元アレキ検出器を用いたヘリカルスキャン方式のCTで、簡易にしてアーチファクトの少ない再構成方法が存在していない。本発明の目的は、2次元アレキ検出器を用いたヘリカルスキャン方式のCTで、簡易な処理でアーチファクトの少ない再構成画像を作成可能なCTを提供することである。

【課題を解決するための手段】本発明は、2次元アレイ検出器を用いてヘリカルスキャンにより投影データを取捨するコンピュータ断層撮影装置において、実際に得られた2次元状の投影データから任意に定めた仮想平面の位置に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。

【作用】本発明によれば、実際に得られた２次元状の投影データから任意に定めた仮想平面の位置に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成するので、２次元アレイ検出器を用いたヘリカルスキャン方式のCTで、簡易な処理でアーチファクトの少ない再構成画像を作成することができ、

【実施例】以下、本発明によるコンピュータ断層撮影装置（以下、「CT」と略す）の一実施例を説明する。図1は本実施例に係るCTの構成図であり、図2は図1のデータ前処理装置のブロック図である。CTは、大きく架台1、寝台2、コンソール3から構成される。架台1の中心部には、円筒形の開口部が開けられ、スキャン時には被検体Pが寝台2に設置された状態で挿入される。なお、被検体Pの体軸方向に平行な水平軸をZ軸、鉛直軸をY軸、Z軸に直交する水平軸をX軸と定義する。寝台2は寝台駆動装置20に駆動されて被検体Pを設置したままで移動可能に構成される。X線源10は、高電圧発生装置4から高電圧を受けて、扇状のX線ビームFXをばく射する。この扇状のX線ビームFXの広がりを角度をファン角度といい、中心軸を挟んで左右に±A°、合計2A°とする。典型的な例として、ファン角度は50°に設定されている。2次元アレイ検出器12は、被検体Pを透過したX線を電気信号として検出する検出器を2次元状に配列している。X線源10と2次元アレイ検出器12とは、図示しない回転機構及びスリッピング機構によって、対向した状態のまま被検体Pの周囲を連続回転可能に支持されている。この回転は架台駆動装置13によって駆動される。2次元アレイ検出器12の出力は2次元データ収集装置12で時間的に積分され、ディジタル化されて投影データとして収集される。高電圧発生装置4は高電圧制御装置5に、架台駆動装置13は架台制御装置3に、寝台駆動装置20は寝台制御装置34にそれぞれ制御される。

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【００１１】次に本実施例の作用について説明する。なお、説明の便宜上、被検体Ｐと共に移動する移動座標系を指定する。この移動座標系において、ヘリカルスキャンではＸ線源１０は図３（ａ）に示すように螺旋軌道をもつて移動することになる。実際の動きでは、Ｘ線源１０及び２次元アレイ検出器１１が連続回転しながら、夜台２により被検体Ｐが一方方向に移動する。ここで、以下の説明で扱う特用語語について定義する。

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<http://www4.ipdl.jpo.go.jp/tjcontenttrns.ipdl?N0000=21&N0400=image/gif&N0401=/NS> 3/30/2004

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線源 10 の螺旋軌道に沿って少しずつずらしながら、再構成処理を繰り返すことにより得られる。この斜断面の移動ピッチに応じて空間分解能が変化する。例えば、図 4 に 90° ずつずらした斜断面の変化を示す。この方法によれば、例えば 1 回転で、これまで実用化されているシングルスライスあるいはデュアルスライスのヘリカル CT の数倍分（移動ピッチに応じて変化する）の画像を再構成することができる。

【0014】以下に詳細に説明する。

・再構成すべき仮想平面（斜断面）の設定について
X線源 10 が 180° 回転する間に移動する X 線バス群により、斜断面が近似的に規定されることを上述したが、最も近似する上記ずれ量の最小となる仮想平面を特定する必要がある。図 6 に X 線源 10（ソース）の螺旋軌道を横軸を X 線源 10 の回転角、縦軸を Z 座標として表現している。X 線源 10 の螺旋軌道はこのグラフ上では原点を通る 1 次の直線 f_{source} で示される。一方、仮想平面は、このグラフ上ではサインカーブ f_{plane} として示される。ここでは、 0° を中心に $180^\circ + \text{ファン角度 } 2A$ 、つまり $\pm(90^\circ + A)$ 分がハーフ再構成に必要なビューとして与えられる。 f_{source} と f_{plane} の差の積分が小さい程、仮想平面と、X 線源 10 の螺旋軌道の半回転分の X 線バス群で描かれる湾曲面とのずれ量が小さいことは容易に理解されるであろう。

【0015】例えば、ファン角度 $2A = 50^\circ$ とすると、 $90^\circ + A = 115^\circ$ となるが、このとき仮想平面の傾斜角（グラフ上はサインカーブ f_{plane} の 0° 度での傾きに相当）と、ヘリカルスキャン時の X 線源 10 の回転に対する表台 2 の相対移動速度に応じた f_{source} の傾きの比が 1.095 であるとき、両関数の差分 $d1$ 、 $d2$ がほぼ一致する。すなわち両関数の差の絶対値の最大値（ $|d1 - d2|$ ）が、最小になるように、仮想平面を設定することにより、最もアーチファクトの少ない最適な仮想平面を特定することが可能である。このように両関数の差の絶対値の最大値に基づく方法の他に、両関数の差分の 2 乗平均が最小となるように仮想平面を設定する方法を採用してもよい。勿論、このような 2 つの方法に限定されるものではない。

【0016】・近似バスの設定について

図 6 を参照して理解されるように、仮想平面内に含まれる仮想バスは数少であり、したがって仮想投影データは実在投影データとしてはほとんど存在しない。したがって、一定の厚みを持った扇状の X 線ビーム内における、仮想バスと最も近い近似バスを設定する。ここで、ファン内角度 0° について考えると、図 7 のように FOV（Field of View）の中心（X 線源 10 の回転中心と同じ）を通る仮想平面上のバスが仮想バスである。一方、近似バスは、X 線源 10 から FOV 中心を通るバスとして与えられる。この近似バスを通る実在投影データがファン内角度 0° に関する近似投影データと

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される。この近似バスを通る実在投影データ存在しなければ、当該近似バスと検出器面との交点に最も近いチャンネル A、B の 2 つの実在投影データから補間により近似投影データを作成する。図 5 に、回転角度の変化に対する近似バスの検出面の交点群の変化を太線で概念的に示す。近似バスの設定方法について、2 種類の具体例を提供する。

【0017】（1）第 1 の近似バスの設定方法（図 8（a）参照）

この方法では、X 線源 10 の或る回転角について見ると、近似バスの検出面上への交点がファン内角度の変化に伴って「直線」で描かれることになる。上述したようにファン内角度 0° の近似バスは FOV 中心で仮想平面と交差するように設定される。他のファン内角度の近似バスと仮想平面との交点が、X 線源 10 を中心として X 線源 10 から FOV 中心までを半径とした仮想平面の僅かに扁平な楕円を描くように、近似バス群が設定される。この方法の利点は、実際の計算の煩雑度が小さいことが挙げられる。図 9 に、この方法による 1 枚の断面像を再構成するのに必要な全ての近似バスを示している。なお、図 9 では、X 線源 10 の回転角度とは絶対角度ではなく、X 線源 10 が再構成に用いる半回転の中心を 0° として表し、また Z 位置 ρ は X 線源 10 が半回転する間に表台 2 が移動する移動範囲の中心位置を原点として、原点からの距離 (mm) で表して、X 線源 10 の回転角度及び検出器の Z 位置の移動の変化に対して汎用化して示している。図 9 では X 線源 10 が半回転する間に表台 2 が 40mm 移動するように示している。図 9 の見方は、例えば X 線源 10 の回転角度 α が 0° で、ファン内角度 α が 0° のときの近似バスは、Z 位置 ρ が 0 の投影データであり、これは通常、実在するであろう。勿論、この Z 位置 ρ の実在バスが実在しなければ、近似投影データは当該近似バスに最も近い 2 つのバス上の実在投影データから補間により作成される。

【0018】（2）第 2 の近似バスの設定方法（図 8（b）参照）。

この方法は、近似バスの中心で仮想平面と交わるように近似バスを設定する。このような近似バスと仮想平面との交点は、X 線源 10 と FOV 中心との距離を直径とする XY 面上の円周を Z 軸方向に延長した円筒と、仮想平面である斜断面とが交差する僅かな楕円を描く。勿論、この近似バスの実在投影データが存在しなければ、上述したように補間により作成する。

【0019】以上、近似バスの設定、換言すると近似投影データの作成例を 2 つ挙げたが、他にも変形例が考えられ、ここであげた 2 つの例に制約されるものではない。なお、補間に関して、回転角度とファン内角度の組み合わせ毎に、補間係数をあらかじめ求めておくことは、近似投影データの作成に当たって、補間係数の計算工程が不要とされ、計算量の軽減という観点から有効と

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いえる。さらに、仮想平面の設定、近似バスの取り方についても、運用上は上記補間係数にすべて繰り込むことができる。

【0020】次に具体例を挙げて説明する。ここでは、X線源10の回転半径を600mm、X線源10から2次元アレイ検出器11までの距離を1.1m、ファン角度を50度と仮定する。このときFOV（再構成領域）は $600 \times \sin(50^\circ/2)$ で、約250mmになる。また、2次元アレイ検出器11は、2方向（スライス方向）に9チャンネル、換言すると1次元アレイ検出器が2方向に9列設けられたものであると仮定する。また、1次元アレイ検出器は、FOV中心においては1.4mm間隔に相当する列ピッチ（このとき列ピッチは2.57mmとなる）で配列されていると仮定する。また、X線源10が1回転する間に検出器2の移動量は15mmであると仮定する。このときのFOV内での近似バスと仮想平面の2方向のずれは、計算によりプラス方向もマイナス方向も0.41mm程度と見積もれる。記憶部312からの近似投影データの取り出しは、図9にしたがって行われる。補間処理は、線形距離補間でもよいし、 $r = \sin \cos$ 関数を用いた補間のいずれでもよい。2次元アレイ検出器11上でのデータの必要範囲はプラスマイナス10.18mmと見積もれ、検出器11の存在範囲 $2.57 \text{ mm} \times 4 = 10.28 \text{ mm}$ の中に入る。近似投影データ作成時に補間処理が入るため、FOV中心でのチャンネルの幅1.4mmに対して実行スライス厚はもっと厚く2mm程度になるであろう。このとき先の2方向のエラー0.41mmは適当に小さいエラーであり、画質的に大きなアーチファクトを発生させるに至らないと理解される。

【0021】次に画像再構成について説明する。近似投影データから2次元のハーフ画像再構成を行えば画像が得られる。実際の処理としては、上述のようにして得られた近似投影データに対して従来通りの2次元ハーフ再構成を施すのみでよい。このとき、180度+ファン角度分のデータを使うと、対向ビームが若干得られるが、この両者を加算平均してもよいし、一方を選択してもよい。もちろん、もう少し広い角度範囲でデータを取得し、対向ビームを「滑らかに重み付けて繋ぐ」ようにしてもよい。

【0022】ところで、再構成の座標系は2方向に垂直なX、Y軸について再構成を行えばよく、これにより再構成面はわずかに傾きを持つが、これを2方向から眺めた画像として得られる。仮想平面内の2次元座標を取り直すなどする必要はない。もともとデータのX、Y座標で収集されているということもあるし、また上述したように連続する再構成面が非平行であるので、かえってX、Y座標のままの方が3次元データとしての扱いが容易であると考えられる。

【0023】ボリュームデータの収集について

以上の説明では、単一スライスの取得を中心に述べてきた。ボリュームデータを得るには、1枚の画像を再構成するのに必要な半回転範囲を、少しずつしてやればよい（図3（a）参照）。例えばX線源10の1回転の間に8枚の画像が欲しい場合には、 $360^\circ/8 = 45^\circ$ のピッチで半回転範囲をずらして仮想平面を設定すればよい。

【0024】さて、X線源10の螺旋軌道に沿ってたとえば45度ピッチで順次画像を作成したとしても、得られる画像は非平行である。このため空間分解能がXY方向に変化するが、これは元々のX線源10の螺旋軌道の空間的な非対称性を反映したものと考えられその意味でごく自然なものであるといえる。

【0025】得られた一連の画像は非平行なので、互いに平行な断面や、曲面変換像を含む断面変換像など、任意の2次元像を切り出す必要がある。各面は後述するP（ ξ ）の式によってその位置が与えられているのでこれに従って、算出すればよい。また、表面表示や投影像作成などの3次元画像処理を行う場合、互いに平行な断面を一旦作成してから、これを用いて処理を行うのが実際の運用上は最も便利であるが、精度を上げたい場合には得られた一連の非平行画像から直接処理を行うのがよい。

【0026】ヘリカルCT、及び2スライスのマルチスライスを行うデュアルスライスヘリカルCTに関して従来法と比較する。まず撮像のスピード・収集時間の効率について。先に示した例では、ヘリカルCTでは、例えば10cm分の厚みを持つ領域を2mmスライスデータとして欲しければ、1回転あたり検出器を2mm移動させ、50回転の撮影が必要であった。デュアルスライスのものであれば、1回転あたり4mm移動させ25回転が必要である。本法を用いれば、上記の具体的な計算例では、1回転あたり検出器を15mm移動させるので、7回転程度で済むことになる。次に再構成時のFOV内の投影ビームの存在位置のエラーについて考えよう。本法は近似手法であり、エラーは存在するが、上記具体的な計算例で示した例のように、適切な条件下では、十分な精度を待たせることができる。従来のヘリカルCTにおいても、隣接データとの補間処理は行っており、本法を用いても、従来法と同程度のエラーにて実行できるといえる。

【0027】図10はデータ収集から再構成までの一連の処理の流れを示すフローチャートであり、図11に或る斜断面を示す。1回転あたりの検出器移動量をh[mm]、仮想平面の傾きを κ とすると、 ξ radian回転した位置、すなわち $(\xi h/2\pi)$ [mm]の位置を中心とした斜断面P（ ξ ）は

$$P(\xi) = \{ (x, y, z) \mid z = (\xi h/2\pi) + [(x, y) \cdot (-\sin \xi, \cos \xi)] \times \tan \kappa \}$$

で与えられる。ただし、「 \cdot 」は内積を表す。

【0028】ここで、X線源10の回転角度 θ 、ファン

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内角度 α 、2方向の位置 ρ とすると、この近似投影データを $R(\beta, \alpha, \rho)$ と表すものとする。実際には、投影データは離散的に得られるので、 $R(I(\Delta\beta), m(\Delta\alpha), n(\Delta\rho))$ として表現される。なお、 $m = -M/2 \sim +M/2$ 、 $n = -N/2 \sim +L/2$ である。

【0029】ヘリカルスキャンによりX線源10は数回転するので、 β は広範囲となる。この範囲1を、 $I = L1 \sim L2$ とする。また、ハーフ再構成に必要な範囲である真角度で $-(\pi/2 + A) \sim (\pi/2 + A)$ に対応した範囲を $-L/2 \sim +L/2$ と記述する。

【0030】さて、X線源10が ξ だけ回転した位置における斜断面の再構成について考えよう。この斜断面の再構成画像 $H(\xi)$ を再構成するために必要な全近似投影データの近似バスの検出器上の2位置 ρ は、 β と α の開数として $\rho(\beta, \alpha)$ として与えられる。

【0031】 $H(\xi)$ は、次のように得られる。

(STEP1) 斜断面の近似投影データ $R(\xi, \beta, \alpha)$ は、

$$R(\xi, \beta, \alpha) = R(\xi + \beta, \alpha, \rho(\beta, \alpha))$$

で作成される。このとき、

$$\xi + \beta = (I(\xi)) \cdot (\Delta\xi)$$

$$\alpha = (m(\xi)) \cdot (\Delta\alpha)$$

$$(n-1) \cdot (\Delta\rho) \leq \rho(\beta, \alpha) < n \cdot (\Delta\rho) \text{ と}$$

すると、実際には、

$$R(I(\xi) \cdot (\Delta\xi), m(\xi) \cdot (\Delta\alpha), \alpha,$$

$$(n-1) \cdot (\Delta\rho))$$

$$R(I(\xi) \cdot (\Delta\xi), m(\xi) \cdot (\Delta\alpha), \alpha, n \cdot (\Delta\rho))$$

の2つの真投影データから補間処理により近似投影データが作成される。

(STEP2) 近似投影データ $R(\xi, \beta, \alpha)$ を用いて所定のハーフ再構成アルゴリズムにより、 ξ だけ回転した方向に画像 $H(\xi)$ を再構成する。

【0032】なお、近似投影データ R はヘリカルスキャンの実行中に順次必要な画像の再構成が終了次第、順次、消去してよいし、記憶部312の記憶容量が十分大きければ、ヘリカルスキャン終了後、再構成処理を実行するようにしてもよい。

【0033】本発明は上述した実施例に限定されず種々変形して実施可能である。以下に変形例を順次説明する。

(1) シフト機構の併用

本発明とシフト機構を併用することによって、分解能を向上させることができる。例えばX線源10の回転半径を上述の例の600mmを2/3の400mmになるように「シフト」させたい。本発明においては、これに連動してX線源101回転あたりの寝台の移動量も15mmから2/3の10mmに、スライス厚みも2/3とさせる。必ずしも連動させる必要はないが、スライス方向含めて全体的に分解能を向上させるのが最も効率がよ

い。

【0034】(2) 部分角再構成法の利用

本発明の基本的アイデアは、X線源10の螺旋軌道の180°回転分程度は1つの平面に近似的に含まれることに着目し、このヘリカル斜断面に近いプロジェクションデータを抜き出し集めて、通常の2次元のハーフ再構成を行おうと言うものであった。螺旋軌道を一部分に限局すれば、その分近似はよくなる。本発明の変形例として、部分角再構成法を併用する。この方式を用いればX線源10の螺旋軌道と仮想平面の位置的な近似はきわめてよくなるので、仮想平面が更に傾斜角度を持っていても画像を得ることができる。従って「スライス方向のファン角度」も大きくすることが可能であり、撮影の効率も向上する。

【0035】(3) 逆回転(寝台逆方向移動)への対応
実際の装置では、寝台の移動方向は、CT架台に挿入する方向、引き出す方向の双方向で使用する可能性がある。またX線源10の回転方向自体も逆回転含めて2通りが考えられる。この場合、被検体に対するX線源10の相対的な螺旋運動は鏡像対称であるので、上記のデータ処理(近似投影データの作成、逆投影演算の座標など)すべて鏡像対称とする。

【0036】

【発明の効果】本発明は、2次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、実際に得られた2次元状の投影データから任意に定めた仮想平面の位置に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。本発明によれば、実際に得られた2次元状の投影データから任意に定めた仮想平面の位置に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成するので、2次元アレイ検出器を用いたヘリカルスキャン方式のCTで、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。

【図面の簡単な説明】

【図1】本実施例に係るCTの構成図。

【図2】図1のデータ前処理装置のブロック図。

【図3】ヘリカルスキャンにおけるX線源の螺旋軌道を示す図。

【図4】90°ずつずらした斜断面の変化を示す図。

【図5】回転角度の変化に対する近似バスの検出面の交点群の変化を示す概念図。

【図6】X線源の螺旋軌道と仮想平面の装置を示す図。

【図7】ファン内角度0°の仮想バスと近似バスを示す図。

【図8】近似バスの設定方法の説明図。

【図9】1枚の断層像を再構成するのに必要な全ての近似バスの2位置を示す図。

【図10】データ収集から再構成までの一連の処理の流れ

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れを示すフローチャート。

【図11】図10に対応する斜断面を示す図。

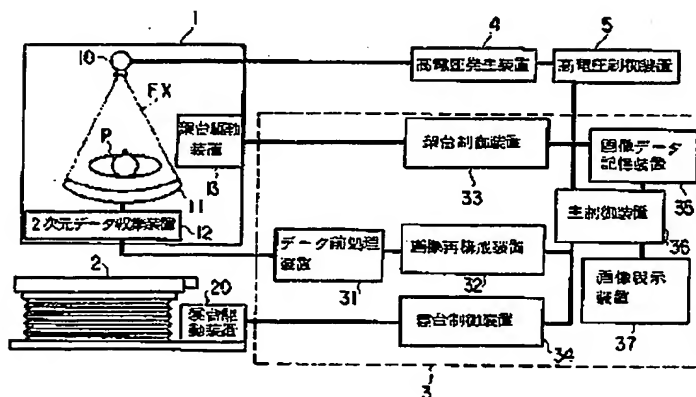
【符号の説明】

1…架台、
2…複台、3…コンソ
ール、
4…高電圧発生装置、5…高電圧
制御装置、
10…X線源、11…2次元アレ*

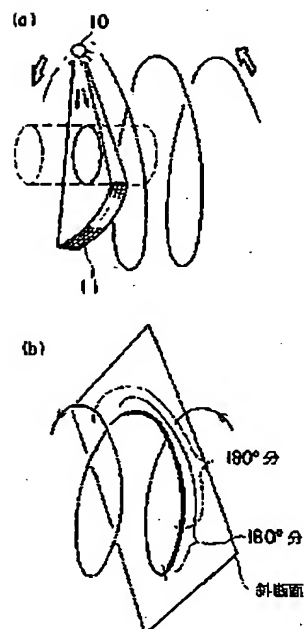
*イ検出器、
器、
構成装置、
御装置、
主制御装置、

3…架台駆動装置、20…複台駆動装
置、
31…データ前処理装置、32…画像再
構成装置、
33…架台制御装置、34…複台制
35…画像データ記憶装置、36…
37…画像表示装置。

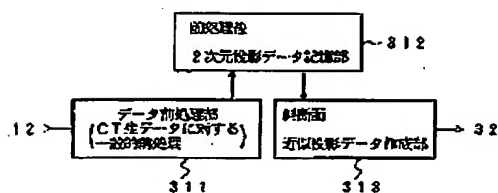
【図1】



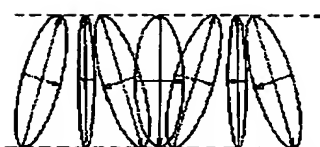
【図3】



【図2】



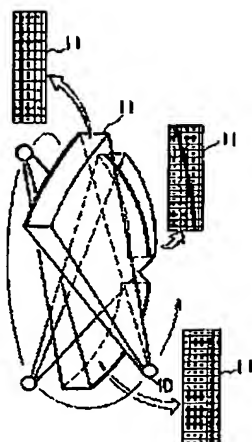
【図4】



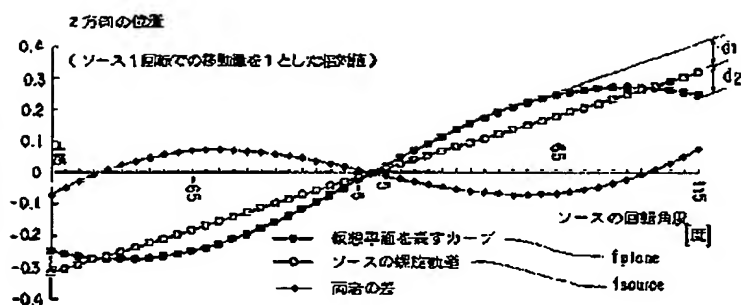
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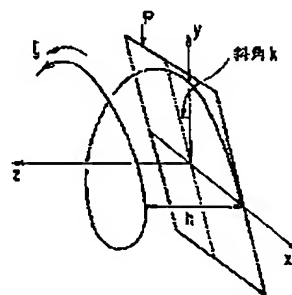
【図5】



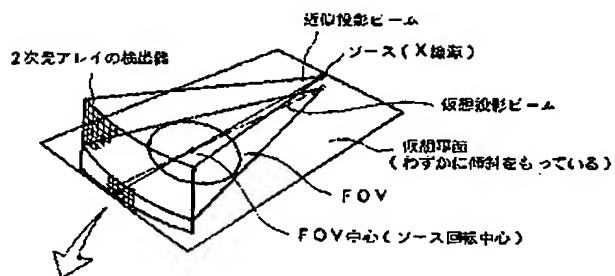
【図6】



【図11】



【図7】



回転後の仮想平面(再構成面) $P(\xi)$

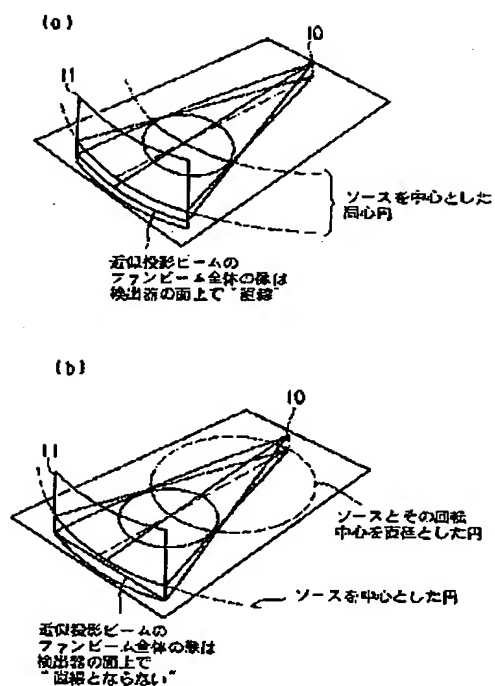
$$P(\xi) = (x, y, z) \mid z = (h/2) + ((x, y) \cdot \sin \xi, \cos \xi) \times \tan k$$

「近似投影ビーム」と検出器の文点
実在するチャンネルA、目の投影データから制関により
「近似投影データ」を作成する

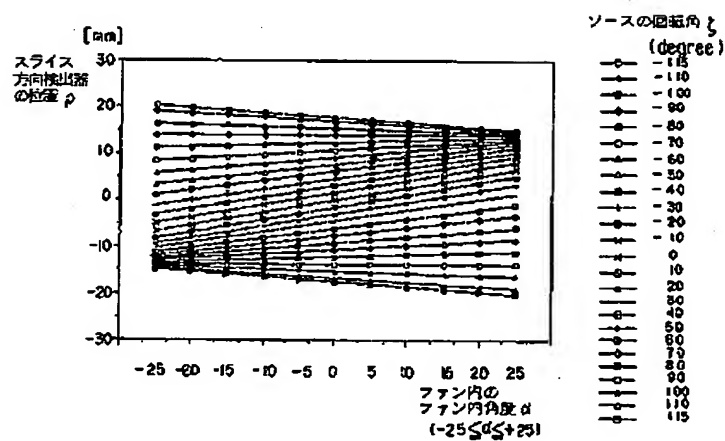
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【図8】



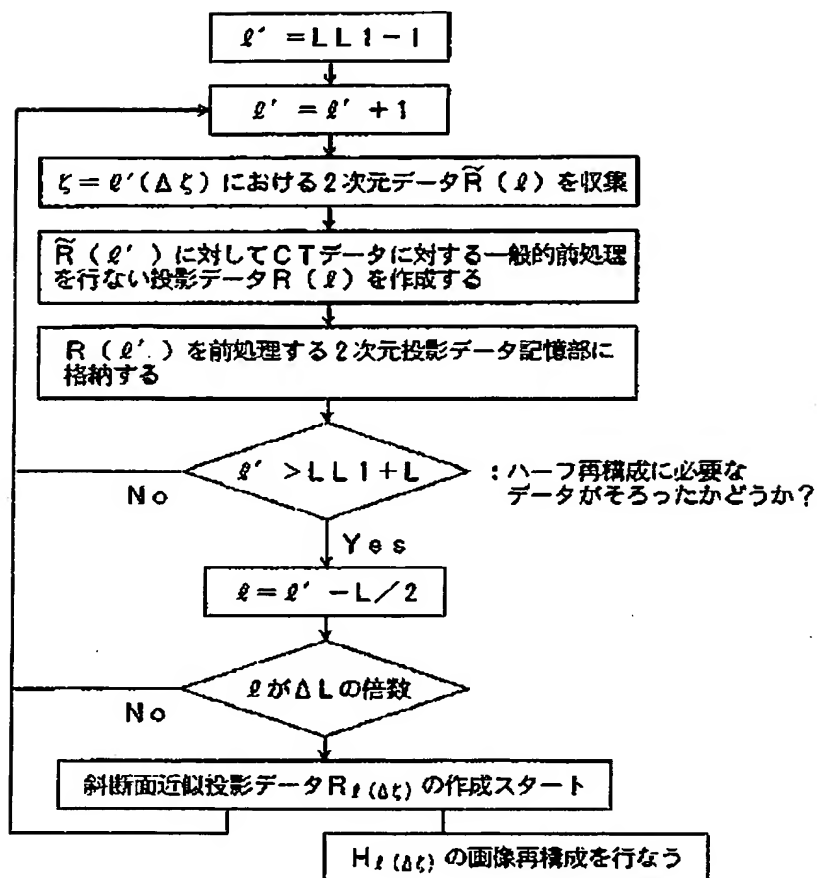
【図9】



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【図10】



(収集と同時再構成の場合は、 $\ell = \Delta L$ おきの時間内に、再構成まで終了) する必要がある。

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【手続補正音】

【提出日】平成14年1月10日(2002.1.10)

【手続補正1】

【補正対象音類名】明細書

【補正対象項目名】特許請求の範囲

【補正方法】変更

【補正内容】

【特許請求の範囲】

【請求項1】 2次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、前記投影データから、設定された再構成面に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とするコンピュータ断層撮影装置。

【請求項2】 前記近似投影データを同時に収集されたスライス方向に隣接する少なくとも2つの実像に得られた投影データの補間により求めることを特徴とする請求項1記載のコンピュータ断層撮影装置。

【請求項3】 前記再構成面は前記ヘリカルスキャンの中心軸に対して傾斜する斜断面として設定されることを特徴とする請求項1記載のコンピュータ断層撮影装置。

【請求項4】 前記再構成面を空間的に連続するように複数設定し、各再構成面について再構成像を再構成することによりボリュームデータを得ることを特徴とする請求項1記載のコンピュータ断層撮影装置。

【請求項5】 前記ヘリカルスキャンはX線源が被検体に対して相対的に螺旋軌道上を移動することにより実行され、前記再構成面を前記X線源が略180度回転する間の複数のX線バスにより描かれる湾曲面に近似する平面として設定されることを特徴とする請求項1記載のコンピュータ断層撮影装置。

【請求項6】 前記再構成面を、半螺旋の各回転角にお

ける前記X線源のZ座標と、前記X線源の螺旋軌道により規定される円筒と前記再構成面とが交差する楕円のZ座標との差の絶対値の最大値が、最小になるように設定することを特徴とする請求項5記載のコンピュータ断層撮影装置。

【請求項7】 前記再構成面を、半螺旋の各回転角における前記X線源のZ座標と、前記X線源の螺旋軌道により規定される円筒と前記再構成面とが交差する楕円のZ座標との差の二乗平均誤差が、最小になるように設定することを特徴とする請求項5記載のコンピュータ断層撮影装置。

【請求項8】 前記近似投影データは、前記X線源とF O V中心との距離を直径とする円筒と、前記再構成面の交差する楕円上を通過するX線バス上のデータであることを特徴とする請求項5記載のコンピュータ断層撮影装置。

【請求項9】 前記近似投影データは、前記X線源を中心にしてF O V中心を通る円筒と前記再構成面の交わる楕円を通過するX線バス上のデータであることを特徴とする請求項5記載のコンピュータ断層撮影装置。

【請求項10】 前記2次元アレイ検出器のスライス方向の幅から換算したF O V中心でスライス方向の再構成厚みをcとしたとき、前記X線源の1回転での被検体の相対的移動距離を略1.5cに設定することを特徴とする請求項5記載のコンピュータ断層撮影装置。

【請求項11】 前記再構成は部分角再構成法を利用したものであることを特徴とする請求項1記載のコンピュータ断層撮影装置。

【請求項12】 前記近似するX線バスは、X線源の回転角度に応じて決められることを特徴とする請求項1記載のコンピュータ断層撮影装置。

【請求項13】 X線を照射するX線源と、被検体を透

- 補 1 -

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過したX線を検出する検出器が2次元状に配列された2次元検出器と、

前記2次元検出器の信号から前記被検体の投影データを収集するデータ収集装置と、

このデータ収集装置からの投影データを用いて、設定された再構成面の画像を再構成するのに必要な前記再構成面に近似するX線バスの近似投影データを作成するデータ作成部と、

前記近似投影データを用いて前記再構成面の画像を再構成する再構成装置と、を備えたことを特徴とするコンピュータ断層撮影装置。

【手続補正2】

【補正対象書類名】明細書

【補正対象項目名】0007

【補正方法】変更

【補正内容】

【0007】

【課題を解決するための手段】本発明は、2次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、前記投影データから、設定された再構成面に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。

【手続補正3】

【補正対象書類名】明細書

【補正対象項目名】0008

【補正方法】変更

【補正内容】

【0008】

【作用】本発明によれば、2次元アレイ検出器を用いてヘリカルスキャンにより得られた2次元状の投影データから、設定された再構成面に近似するX線バスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成するので、2次元アレイ検出器を用いたヘリカルスキャン方式のCTで、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。

【手続補正4】

【補正対象書類名】明細書

【補正対象項目名】0015

*

$$P(\xi) = \{ (x, y, z) \mid z = (\xi h / 2\pi) + [(x, y) \cdot (-\sin \xi, \cos \xi)] \times \tan \kappa \}$$

で与えられる。ただし、「 \cdot 」は内積を表す。

【手続補正7】

【補正対象書類名】明細書

【補正対象項目名】0036

【補正方法】変更

*【補正方法】変更

【補正内容】

【0015】例えば、ファン角度 $2A = 50^\circ$ とすると、 $90^\circ + A = 115^\circ$ となるが、このとき仮想平面の傾斜角（グラフ上はサインカーブplaneの0度での傾きに相当）と、ヘリカルスキャン時のX線源10の回転に対する搬台2の相対移動速度に応じたfsourceの傾きの比が $1.095 \times (\pi/2) = 1.726$ であるとき、両関数の差分 $d1$ 、 $d2$ がほぼ一致する。すなわち両関数の差の絶対値の最大値 $(|d1 - d2|)$ が、最小になるように、仮想平面を設定することにより、最もアーチファクトの少ない最適な仮想平面を特定することが可能である。このように両関数の差の絶対値の最大値に基づく方法の他に、両関数の差分の2乗平均が最小となるように仮想平面を設定する方法を採用してもよい。勿論、このような2つの方法に限定されるものではない。

【手続補正5】

【補正対象書類名】明細書

【補正対象項目名】0024

【補正方法】変更

【補正内容】

【0024】さて、X線源10の螺旋軌道に沿ってたとえば45度ピッチで順次画像を作成したとしても、得られる画像は非平行である。このためZ方向の空間分解能が一定ではなく変化するが、これは元々のX線源10の螺旋軌道の空間的な非対称性を反映したものと考えられその意味でごく自然なものであるといえる。

【手続補正6】

【補正対象書類名】明細書

【補正対象項目名】0027

【補正方法】変更

【補正内容】

【0027】図10はデータ収集から再構成までの一連の処理の流れを示すフローチャートであり、図11に或る斜断面を示す。1回転あたりの搬台移動量を h [mm]、仮想平面の傾きを κ とすると、 ξ radian回転した位置、すなわち $(\xi h / 2\pi)$ [mm]の位置を中心とした斜断面 $P(\xi)$ は

【補正内容】

【0036】

【発明の効果】本発明によれば、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。

* NOTICES *

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CLAIMS

[Claim(s)]

[Claim 1] The computerized-tomography scanning equipment characterized by extracting the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data in the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, and reconfiguring a reconstruction image using this approximation projection data.

[Claim 2] The computerized-tomography scanning equipment according to claim 1 characterized by asking for said approximation projection data with interpolation of at least two actually obtained projection data which adjoins in the slice direction collected by coincidence.

[Claim 3] Said virtual flat surface is a computerized-tomography scanning equipment according to claim 1 characterized by being set up as a slanting cross section which inclines to the medial axis of said helical scan.

[Claim 4] The computerized-tomography scanning equipment according to claim 1 which carries out the multi-statement of said virtual flat surface so that it may continue spatially, and is characterized by obtaining volume data by reconfiguring a reconstruction image about each virtual flat surface.

[Claim 5] Said helical scan is a computerized-tomography scanning equipment according to claim 1 characterized by being set up as a flat surface approximated to the curve side drawn with two or more X-ray pass while it performs when X line source moves relatively to analyte in a spiral orbit top, and said X line source rotates said virtual flat surface 180 abbreviation.

[Claim 6] The computerized-tomography scanning equipment according to claim 5 characterized by the maximum of the absolute value of a difference with the Z coordinate of the ellipse which the Z coordinate of said X line source in each angle of rotation of a half-spiral, and the cylinder specified by the spiral orbit of said X line source and said virtual flat surface intersect setting up said virtual flat surface so that it may become min.

[Claim 7] The computerized-tomography scanning equipment according to claim 5 characterized by setting up said virtual flat surface so that the mean square error of a difference with the Z coordinate of the ellipse which the Z coordinate of said X line source in each angle of rotation of a half-spiral, and the cylinder specified by the spiral orbit of said X line source and said virtual flat surface intersect may become min.

[Claim 8] Said approximation projection data is a computerized-tomography scanning equipment according to claim 5 characterized by being data on the X-ray pass which passes through the cylinder [which makes a diameter distance of said X line source and FOV core], and ellipse top which said virtual flat surface intersects.

[Claim 9] Said approximation projection data is a computerized-tomography scanning equipment according to claim 5 characterized by being data on the X-ray pass which passes the ellipse at which said virtual flat surface crosses the cylinder which passes along a FOV core focusing on said X line source.

[Claim 10] The computerized-tomography scanning equipment according to claim 5 characterized by setting the relative movement distance of the analyte in one rotation of said X line source as abbreviation 1.5c when reconstruction thickness of the slice direction is set to c focusing on FOV converted from the width of face of the slice direction of said two-dimensional-array detector.

[Claim 11] Said reconstruction is a computerized-tomography scanning equipment according to claim 1 characterized by using a partial angle reconstruction method.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the computerized-tomography scanning equipment (it abbreviates to "CT" below) of a helical scan.

[0002]

[Description of the Prior Art] Generally CT with the 1-dimensional detector which arranged the detector which detects the X-ray which penetrated current and analyte to one dimension has spread. And in recent years, the so-called helical scan which X line source draws a spiral orbit and moves in the moving coordinate which moves with a berth by moving a berth, carrying out continuation rotation of X line source (source) and the detector is beginning to spread quickly. Furthermore, the formation of many trains of a 1-dimensional detector and cone beam-ization of an exposure X-ray grope for the implementability of three-dimension-izing of data.

[0003] In the helical scan by the 1-dimensional detector, in order that X line source may move a spiral orbit, it is required to carry out interpolation creation of the great portion of projection data on a reconstruction cross section in approximation by linear interpolation processing etc. This created data is hereafter called approximation projection data. Since the data for one rotation were substantially needed, when reconstruction wanted the field which has the thickness for 10cm, for example as 2mm slice data, it needed the scan of 50 rotations.

[0004] As for 2 successive installation beam ***** dual slice helical method, a data collection rate becomes twice the above-mentioned method theoretically about a 1-dimensional detector. Although it is possible to develop this and to form a 1-dimensional detector into many trains, it becomes impossible for the X-ray pass between trains to regard it as parallel. It will consider that this is parallel temporarily and will become the image which does not bear practical use with much artifact in having reconfigured the image as a multi-slice for every train simply. The current proposal of the technique of conquering these problems was not made, therefore twice [at most] as many improvement in the speed as this has concluded that it is a limit by this method.

[0005] By the cone beam scanning method, when analyte is completely contained in a cone beam, perfect reconstruction is theoretically possible, but when analyte is not completely contained in a cone beam, the solution method of suitable reconstruction is not proposed.

[0006]

[Problem(s) to be Solved by the Invention] As mentioned above, by CT of the helical scan using a two-dimensional-array detector, it simplifies and few reconstruction approaches of the artifact do not exist. The purpose of this invention is CT of the helical scan which used the two-dimensional-array detector, and is offering CT which can create few reconstruction images of the artifact by simple processing.

[0007]

[Means for Solving the Problem] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfiguring a reconstruction image using this approximation projection data.

[0008]

[Function] Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigured using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

[0009]

[Example] Hereafter, one example of the computerized-tomography scanning equipment (it abbreviates to "CT" hereafter) by this invention is explained. Drawing 1 is the block diagram of CT concerning this example, and drawing 2 is the block diagram of the data pre-treatment equipment of drawing 1. CT consists of a stand 1, a berth 2, and a console 3 greatly. Opening of a cylindrical shape can open in the core of a stand 1, and at the time of a scan, where Analyte P is laid in a berth 2, it is inserted in it. In addition, the horizontal axis which intersects perpendicularly a horizontal axis parallel to the direction of a body axis of Analyte P with the Z-axis, and intersects a vertical axis perpendicularly with a Y-axis and the Z-axis is defined as the X-axis. A berth 2 is constituted movable, driving to the berth driving gear 20 and laying Analyte P. The X line source 10 ***** flabellate form X-ray beam FX in response to the high voltage from a high-voltage transformer assembly 4. Whenever [angle-of-divergence / of this flabellate form X-ray beam FX] is called fan include angle, and is made into **A degrees and sum total 2A" on both sides of a medial axis at right and left. As a typical example, the fan include angle is set as 50 degrees. The two-dimensional-array detector 12 comes to arrange the detector which detects the X-ray which penetrated Analyte P as an electrical signal in the shape of two-dimensional. with the condition that the X line source 10 and the two-dimensional-array detector 12 countered according to the rolling mechanism and slip ring device which are not illustrated -- the perimeter of Analyte P -- continuation -- it is supported pivotable. This rotation is driven with the stand driving gear 13. With the two-dimensional data collector 12, it integrates with the output of the two-dimensional-array detector 12 in time, and it is digitized and are collected as projection data. The stand driving gear 13 is controlled by the stand control unit 33, and the berth driving gear 20 is controlled for a high-voltage transformer assembly 4 by the high-voltage control unit 5 at the berth control unit 34, respectively.

[0010] It is sent to the data pre-treatment equipment 31, and the projection data from the two-dimensional data collector 12 is at the data pretreatment section 311 first. After general pretreatment of Log conversion (logarithmic transformation) etc. is performed, the after [pretreatment] two-dimensional projection data storage section 312 memorizes. The slanting cross-section approximation projection data origination section 313 creates approximation projection data required to reconfigure the image about a slanting cross section using the projection data after pretreatment. The image re-component 32 reconfigures an image (slanting cross-section image) from the approximation projection data created in the slanting cross-section approximation projection data origination section 313. The so-called half reconstruction approach which can reconfigure an image from the projection data for 180 degrees is adopted as this reconstruction processing. This tomogram data is sent and displayed on an image display device 37 through the main control section 36, and is sent to the image data storage 35, and is memorized. The main control section 36 controls the high-voltage control unit 5, the stand control unit 33, and the berth control unit 34, and performs helical scan.

[0011] Next, an operation of this example is explained. In addition, the moving coordinate of explanation which moves with Analyte P is specified for convenience. In this moving coordinate, by helical scan, the X line source 10 will move a spiral orbit, as shown in drawing 3 (a). In an actual motion, while the X line source 10 and the two-dimensional-array detector 11 carry out continuation rotation, Analyte P moves to an one direction on a berth 2. Here, the jargon treated by the following explanation is defined.

- Actual existence projection data; projection data on the X-ray pass (it is called a virtual path) which is needed in order to reconfigure the image of the projection data and the virtual projection data; reconstruction side of the actual existence actually collected with each detector of the two-dimensional-array detector 11 (here, it defines as a slanting cross section) and which is included ideal, i.e., the reconstruction side concerned. In helical scan, such virtual projection data does not exist really except for some exceptions.

- Approximation projection data; projection data on the X-ray pass in X-ray beam FX most approximated to a virtual path (it is called approximation pass). In addition, this approximation projection data may not exist really by existing really as actual existence projection data. When it does not exist really, it creates with interpolation (distance interpolation) from the actual existence projection data near approximation pass. Approximation projection data is created by every [of the X-ray from the X line source 10 / one / every] radiation direction (a definition is given as whenever [fan interior angle]) about angle of rotation of each of the X line source 10.

[0012] In addition, two or more X-ray pass required for reconstruction cannot define the flat surface of one sheet in helical scan. One of the descriptions of this example sets up the slanting cross section (reconstruction side) which inclines to the Z-axis to the X-ray pass group for half-rotation of the X line source 10, and it is to reconfigure an image using the projection data for this half-rotation (refer to [drawing 3 \(b\)](#)). Thereby, there are few gaps with the curve side and reconstruction side which are drawn by the X-ray pass group for half-rotation, and they can reconfigure an image with little artifact. Furthermore, the description of this example is setting up the slanting cross section where the artifact's makes min the min of gaps, i.e., the above-mentioned amount, to the X-ray pass group for half-rotation, and setting approximation pass. Approximation pass is specified by Z location angle of rotation of the X line source 10, and whenever [fan interior angle].

[0013] The volume data of a three dimension are obtained by repeating reconstruction processing, shifting a slanting cross section little by little in accordance with the spiral orbit of the X line source 10. Spatial resolving power changes according to the migration pitch of this slanting cross section. For example, change of the slanting cross section which it shifted 90 degrees at a time to [drawing 4](#) is shown. According to this approach, a minute (it changes according to a migration pitch) of an image can be reconfigured, for example by one rotation several times of the helical CT of the single slice put in practical use until now or a dual slice.

[0014] It explains below at a detail.

- Although the slanting cross section mentioned above what is specified in approximation by the X-ray pass group which moves while 180 degrees of X line sources 10 rotate about a setup of the virtual flat surface (slanting cross section) which should be reconfigured, it is necessary to specify the virtual flat surface used as the min of the above-mentioned amount of gaps approximated most. The angle of rotation of the X line source 10 and the axis of ordinate are expressed [the spiral orbit of the X line source 10 (source)] for the axis of abscissa as a Z coordinate to [drawing 6](#). The spiral orbit of the X line source 10 is shown on this graph by the primary straight line fsource passing through a zero. On the other hand, a virtual flat surface is the sign curve fplane on this graph. It is shown by carrying out. Here, $180 \text{ degree} + \text{fan include-angle } 2A$, a part for i.e., $90 \text{ degree} + A$, is given as a view required for half reconstruction focusing on 0 degree. fsource and fplane It will be easily understood that the amount of gaps of a virtual flat surface and the curve side drawn by the X-ray pass group for half-rotation of the spiral orbit of the X line source 10 is small, so that the integral of a difference is small.

[0015] For example, if fan include-angle $2A = 50 \text{ degree}$, it will become $90 \text{ degree} + A = 115 \text{ degree}$, but when the ratio of the tilt angle (a graph top is equivalent to the inclination in 0 times of the sign curve fplane) of a virtual flat surface and the inclination of fsource according to the relative-displacement rate of the berth 2 to rotation of the X line source 10 at the time of helical scan is 1.095 at this time, the difference d1 and d2 of both functions is mostly in agreement. That is, the maximum ($|d1 - d2|$) of the absolute value of the difference of both functions is able to specify few optimal virtual flat surfaces of the artifact most by setting up a virtual flat surface so that it may become min. Thus, the approach of setting up a virtual flat surface so that the root mean square of the difference of both functions other than the approach based on the maximum of the absolute value of the difference of both functions may serve as min may be adopted. Of course, it is not limited to such two approaches.

[0016] - The virtual path contained in a virtual flat surface is rare, therefore virtual projection data hardly exists as actual existence projection data so that I may be understood with reference to [drawing 6](#) about a setup of approximation pass. Therefore, the approximation pass nearest to the virtual path in a flabellate form X-ray beam with fixed thickness is set. Here, when 0 degree is considered whenever [fan interior angle], the pass on the virtual flat surface which passes along the

core (it is the same as the center of rotation of the X line source 10) of FOV (Field of View) like drawing 7 is a virtual path. On the other hand, approximation pass is given as pass which passes along a FOV core from the X line source 10. Let the actual existence projection data which passes along this approximation pass be approximation projection data about 0 degree whenever [fan interior angle]. If actual existence projection data existence is not recognized through this approximation pass, approximation projection data is created with interpolation from two actual existence projection data of the channels A and B nearest to the intersection of the approximation pass and a detector side concerned. A thick wire shows notionally change of the intersection group of the detection side of approximation pass to change of angle of rotation to drawing 5 . Two kinds of examples are offered about the setting approach of approximation pass.

[0017] (1) The setting approach of the 1st approximation pass (refer to drawing 8 (a))

By this approach, when it sees about an certain angle of rotation of the X line source 10, the intersection to the detection side top of approximation pass will be drawn "in a straight line" with change which is whenever [fan interior angle]. As mentioned above, 0-degree approximation pass is set whenever [fan interior angle] so that a virtual flat surface may be intersected focusing on FOV. An approximation pass group is set up so that the slightly flat ellipse of the virtual flat surface where the intersection of the approximation pass of whenever [other fan interior angle] and a virtual flat surface made the radius from the X line source 10 to the FOV core the core [the X line source 10] may be drawn. It is mentioned that whenever [of actual count / complicated] is small as for the advantage of this approach. All approximation pass required to reconfigure the tomogram for one sheet by this approach to drawing 9 is shown. In addition, the angle of rotation zeta of the X line source 10 expresses with drawing 9 the core of half-rotation that not an include angle but the X line source 10 uses for reconstruction absolutely, as 0 degree, and the Z location rho makes a zero the center position of the successive range where a berth 2 moves while the X line source 10 half-rotates. It expresses with the distance (mm) from a zero, and is used widely and shown to change of migration of angle of rotation of the X line source 10, and Z location of a detector. By drawing 9 , while the X line source 10 half-rotates, it is indicated that a berth 2 moves 40mm. The angle of rotation zeta of the X line source 10 of the view of drawing 9 is 0 degree, the Z location rho of approximation pass in case alpha is 0 degree whenever [fan interior angle] is projection data of 0, and, probably, this usually exists really. Of course, if the actual existence pass of this Z location rho does not exist really, approximation projection data is created by interpolation from the actual existence projection data on two pass nearest to the approximation pass concerned.

[0018] (2) The setting approach of the 2nd approximation pass (refer to drawing 8 (b)).

This approach sets approximation pass so that a virtual flat surface may be crossed at the core of approximation pass. The intersection of such an approximation pass and a virtual flat surface draws few ellipses which the cylinder which extended the periphery on XY side which makes a diameter the X line source 10 and distance based on FOV(s) to Z shaft orientations, and the slanting cross section which is a virtual flat surface intersect. Of course, if the actual existence projection data of this approximation pass does not exist, as mentioned above, it creates with interpolation.

[0019] As mentioned above, it is not restrained by a setup of approximation pass, and two examples which could otherwise consider the modification and were raised here although two examples of creation of approximation projection data were given when put in another way. In addition, about interpolation, for every combination of angle of rotation and whenever [fan interior angle], it is made unnecessary [the count process of a interpolation multiplier] in creation of approximation projection data to ask for a interpolation multiplier beforehand, and it can be said from a viewpoint of mitigation of computational complexity that it is effective. Furthermore, a setup of a virtual flat surface and approximation pass can take, and an employment top can be altogether woven into the above-mentioned interpolation multiplier also about the direction.

[0020] Next, an example is given and explained. Here, the distance from 600mm and the X line source 10 to the two-dimensional-array detector 11 is assumed to be 1.1m, and a fan include angle is assumed to be 50 degrees for the radius of gyration of the X line source 10. At this time, FOV (reconstruction field) is $600 \times \sin(50 \text{ degrees}/2)$. It is set to about 250mm. moreover, if the two-dimensional-array detector 11 is put in another way nine channels to a Z direction (the slice direction), a one dimensional array detector will assume that it is 9 successive-installation *****

to a Z direction. Moreover, it is assumed that the one dimensional array detector is arranged with the row pitch (a row pitch is set to 2.57mm at this time) which is equivalent to 1.4mm spacing at a FOV core. Moreover, while the X line source 10 rotates one time, it is assumed that the movement magnitude of a berth 2 is 15mm. A gap of approximation pass within FOV at this time and the Z direction of a virtual flat surface can also estimate the plus direction and minus direction at about 0.41mm by count. Ejection of the approximation projection data from the storage section 312 is performed according to drawing 9. Linearity distance interpolation may be used for interpolation processing, and it is risen. Any of the interpolation using a cosine function are sufficient. The need range of the data on the two-dimensional-array detector 11 can be estimated at double sign 10.18mm, and enters into existence range $2.57\text{mm} \times 4 = 10.28\text{mm}$ of a detector 11. Activation slice thickness will be more thickly set to about 2mm to width of face of 1.4mm of the channel based on FOV(s), in order that interpolation processing may enter at the time of approximation projection data origination. At this time, error 0.41mm of a previous Z direction is a small error suitably, and is understood by not coming to generate the big artifact in image quality.

[0021] Next, image reconstruction is explained. An image will be obtained if two-dimensional half image reconstruction is performed from approximation projection data. As actual processing, it is good only by performing two-dimensional half reconstruction as usual to the approximation projection data obtained as mentioned above. Although an opposed beam will be obtained a little if the data for a 180 degree + fan include angle are used at this time, averaging of these both may be carried out and one side may be chosen. Of course, data are acquired in a little larger include-angle range, and it is good as for a method of "being weighting ***** smoothly" in an opposed beam.

[0022] By the way, that the system of coordinates of reconstruction should just reconfigure about X perpendicular to a Z direction, and a Y-axis, although a reconstruction side has an inclination slightly by this, it is obtained as an image which looked at this from the Z direction. There is no need of restarting the two-dimensional coordinate within a virtual flat surface. Since the reconstruction side which continues as it may say that data from the first are collected by X and Y coordinate and being mentioned above is not parallel, it is thought that the direction with X and Y coordinate is easy to treat as three-dimension data on the contrary.

[0023] The above explanation has described collection of volume data focusing on acquisition of a single slice. What is necessary is just to shift a little half-rotation range required to reconfigure the image of one sheet, in order to obtain volume data (refer to drawing 3 (a)). For example, what is necessary is to shift the half-rotation range in the pitch of $360 \text{ degrees} / 8 = 45 \text{ degrees}$, and just to set up a virtual flat surface between 1 rotations of the X line source 10, in wanting the image of eight sheets.

[0024] Now, the image obtained is not parallel even if it creates an image one by one in a pitch 45 degrees in accordance with the spiral orbit of the X line source 10. For this reason, although spatial resolving power changes in the XY direction, this is considered reflecting the spatial asymmetry of the spiral orbit of the X line source 10 from the first, and it can be said in that semantics that it is very natural.

[0025] Since a series of obtained images are un-parallel, it is necessary to start two-dimensional images of arbitration, such as an parallel cross section and a cross-section conversion image containing a music cross-section conversion image, mutually. What is necessary is just to compute each field according to this, since the location is given by the formula of P (zeta) mentioned later. Moreover, although the employment top with actual processing using this is the most convenient once it creates an parallel cross section mutually when performing three-dimension image processings, such as a surface display and projection image creation, it is good to raise precision to perform direct processing from a series of obtained un-parallel images.

[0026] It compares with a conventional method about helical CT and the dual slice helical CT which performs the multi-slice of 2 slices. About the effectiveness of the speed and the acquisition time of first an image pick-up When he wanted the field which has the thickness for 10cm in helical CT in the example shown previously, for example as 2mm slice data, the berth was moved 2mm per rotation and 50 rotations needed to take a photograph. It is made to move 4mm per rotation, and 25 rotations are required of the thing of a dual slice. If this method is used, since a berth is moved 15mm per rotation, it will end with 7 rotation extent in the above-mentioned example of concrete

count. Next, I will consider the error of a projection beam's in FOV at time of reconstruction existence location. although this method is the approximation technique and an error exists -- the above -- like the example shown in the concrete example of count, sufficient precision can be given under suitable conditions. Also in the conventional helical CT, interpolation processing with contiguous data is performed, and even if it uses this method, it can be said that it can perform in an error comparable as a conventional method.

[0027] Drawing 10 is a flow chart which shows the flow of a series of processings from data collection to reconstruction, and shows a certain slanting cross section to drawing 11. When setting the inclination of h [mm] and a virtual flat surface to κ for the berth movement magnitude per rotation, The slanting cross section P (ζ) centering on the location which carried out zetaradian rotation, i.e., $(\zeta/2\pi)$, the location of [mm], is $P(\zeta) = \{(x, y, z) \mid z = (\zeta/2\pi) + [(x, y)](-\sin \zeta, \cos \zeta) \tan \kappa\}$.

It is come out and given. However, "-" expresses an inner product.

[0028] Here, if it is the angle of rotation β of the X line source 10, whenever [fan interior angle / α], and the location ρ of a Z direction, this approximation projection data shall be expressed as $R(\beta, \alpha, \rho)$. In fact, since projection data is obtained discretely, it is expressed as $R(l(\beta), m(\alpha), n(\rho))$. In addition, it is $m = -M/2 - +M/2$, and $n = -N/2 - +L/2$.

[0029] Since the X line source 10 carries out number rotation by helical scan, β becomes wide range. This range l is set to $l = LL1 - LL2$. Moreover, range corresponding to $-(\pi/2 + \alpha) - (\pi/2 + \alpha)$ at the real include angle which is the range required for half reconstruction - It is described as $L/2 - +L/2$.

[0030] Now, the X line source 10 will consider reconstruction of the slanting cross section in the location which only ζ rotated. The Z location ρ on the detector of the approximation pass of all approximation projection data required in order to reconfigure the reconstruction image H of this slanting cross section (ζ) is given as $\rho(\beta, \alpha)$ as a function of β and α .

[0031] $H(\zeta)$ is obtained as follows.

(STEP1) Approximation projection data $R(\zeta, \beta, \alpha)$ of a slanting cross section is $R(\zeta, \beta, \alpha) = R(\zeta + \beta, \alpha, \rho(\beta, \alpha))$.

It is come out and created. At this time, it is $\zeta + \beta = (I(\zeta)) - (\beta)$.

$\alpha = (m(\zeta)) - (\alpha)$

(n-1) When $-(\rho) \leq \rho(\beta, \alpha) < n(\rho)$, it is $R(I(\zeta) - (\beta), m(\zeta) - (\alpha), \alpha, - (n-1)(\rho))$ in fact.

$R(I(\zeta) - (\beta), m(\zeta) - (\alpha), \alpha, n(\rho))$

Approximation projection data is created by interpolation processing from the actual existence projection data of two β .

(STEP2) Image $H(\zeta)$ is reconfigured with a predetermined half reconstruction algorithm in the direction which only ζ rotated using approximation projection data $R(\zeta, \beta, \alpha)$.

[0032] In addition, as soon as reconstruction of an image required one by one during activation of helical scan is completed, one by one, as long as the storage capacity of the storage section 312 is large enough, it may be made to eliminate approximation projection data R , and to perform reconstruction processing after helical scan termination.

[0033] This invention cannot be limited to the example mentioned above, but can deform variously, and can be carried out. Sequential explanation of the modification is given below.

(1) Resolution can be raised by using together concomitant use this invention of a shift device, and a shift device. For example, the juniper the radius of gyration of the X line source 10 "was shifted" so that 600mm of an above-mentioned example might be set to two thirds of 400mm. This is interlocked with and slice thickness also makes 10mm of 2/3 also set movement magnitude of the berth per X line source 101 rotation to two thirds from 15mm in this method. Although it is not necessary to make it not necessarily interlock, it is most efficient for the whole slice direction ***** target to raise resolution.

[0034] (2) It was what is referred to as that 180-degree rotation part extent of the spiral orbit of the X line source 10 will extract and bring together the projection data near this helical slanting cross section in one flat surface paying attention to being contained in approximation, and the fundamental idea of use this invention of a partial angle reconstruction method will perform the usual two-

dimensional half reconstruction. If the ** office of the spiral orbit is carried out to a part, the part approximation will become good. A partial angle reconstruction method is used together as a modification of this method. Since location-approximation of the spiral orbit of the X line source 10 and a virtual flat surface will become very good if this method is used, an image can be obtained even if the virtual flat surface has whenever [tilt-angle] further. Therefore, "the fan include angle of the slice direction" can be enlarged and the effectiveness of photography improves further.

[0035] (3) the correspondence to inverse rotation (berth hard flow migration) -- in actual equipment, the migration direction of a berth may be used in both directions of the direction inserted in CT stand, and the direction to pull out. Moreover, the hand of cut of the X line source 10 itself can consider two kinds of inverse rotation ***** in this case -- since the relative screw motion of the X line source 10 over analyte is symmetrical with a mirror image -- the above-mentioned data processing (creation of approximation projection data, coordinate of a back projection operation, etc.) -- all are considered as the mirror image symmetry.

[0036]

[Effect of the Invention] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfiguring a reconstruction image using this approximation projection data. Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigured using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the computerized-tomography scanning equipment (it abbreviates to "CT" below) of a helical scan.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] Generally CT with the 1-dimensional detector which arranged the detector which detects the X-ray which penetrated current and analyte to one dimension has spread. And in recent years, the so-called helical scan which X line source draws a spiral orbit and moves in the moving coordinate which moves with a berth by moving a berth, carrying out continuation rotation of X line source (source) and the detector is beginning to spread quickly. Furthermore, the formation of many trains of a 1-dimensional detector and cone beam-ization of an exposure X-ray grope for the implementability of three-dimension-izing of data.

[0003] In the helical scan by the 1-dimensional detector, in order that X line source may move a spiral orbit, it is required to carry out interpolation creation of the great portion of projection data on a reconstruction cross section in approximation by linear interpolation processing etc. This created data is hereafter called approximation projection data. Since the data for one rotation were substantially needed, when reconstruction wanted the field which has the thickness for 10cm, for example as 2mm slice data, it needed the scan of 50 rotations.

[0004] As for 2 successive installation beam ***** dual slice helical method, a data collection rate becomes twice the above-mentioned method theoretically about a 1-dimensional detector. Although it is possible to develop this and to form a 1-dimensional detector into many trains, it becomes impossible for the X-ray pass between trains to regard it as parallel. It will consider that this is parallel temporarily and will become the image which does not bear practical use with much artifact in having reconfigured the image as a multi-slice for every train simply. The current proposal of the technique of conquering these problems was not made, therefore twice [at most] as many improvement in the speed as this has concluded that it is a limit by this method.

[0005] By the cone beam scanning method, when analyte is completely contained in a cone beam, perfect reconstruction is theoretically possible, but when analyte is not completely contained in a cone beam, the solution method of suitable reconstruction is not proposed.

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EFFECT OF THE INVENTION

[Effect of the Invention] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfiguring a reconstruction image using this approximation projection data. Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigured using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As mentioned above, by CT of the helical scan using a two-dimensional-array detector, it simplifies and few reconstruction approaches of the artifact do not exist. The purpose of this invention is CT of the helical scan which used the two-dimensional-array detector, and is offering CT which can create few reconstruction images of the artifact by simple processing.

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MEANS

[Means for Solving the Problem] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfiguring a reconstruction image using this approximation projection data.

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OPERATION

[Function] Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigured using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

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EXAMPLE

[Example] Hereafter, one example of the computerized-tomography scanning equipment (it abbreviates to "CT" hereafter) by this invention is explained. Drawing 1 is the block diagram of CT concerning this example, and drawing 2 is the block diagram of the data pre-treatment equipment of drawing 1. CT consists of a stand 1, a berth 2, and a console 3 greatly. Opening of a cylindrical shape can open in the core of a stand 1, and at the time of a scan, where Analyte P is laid in a berth 2, it is inserted in it. In addition, the horizontal axis which intersects perpendicularly a horizontal axis parallel to the direction of a body axis of Analyte P with the Z-axis, and intersects a vertical axis perpendicularly with a Y-axis and the Z-axis is defined as the X-axis. A berth 2 is constituted movable, driving to the berth driving gear 20 and laying Analyte P. The X line source 10 ***** flabellate form X-ray beam FX in response to the high voltage from a high-voltage transformer assembly 4. Whenever [angle-of-divergence / of this flabellate form X-ray beam FX] is called fan include angle, and is made into **A degrees and sum total 2A" on both sides of a medial axis at right and left. As a typical example, the fan include angle is set as 50 degrees. The two-dimensional-array detector 12 comes to arrange the detector which detects the X-ray which penetrated Analyte P as an electrical signal in the shape of two-dimensional. with the condition that the X line source 10 and the two-dimensional-array detector 12 countered according to the rolling mechanism and slip ring device which are not illustrated -- the perimeter of Analyte P -- continuation -- it is supported pivotable. This rotation is driven with the stand driving gear 13. With the two-dimensional data collector 12, it integrates with the output of the two-dimensional-array detector 12 in time, and it is digitized and are collected as projection data. The stand driving gear 13 is controlled by the stand control unit 33, and the berth driving gear 20 is controlled for a high-voltage transformer assembly 4 by the high-voltage control unit 5 at the berth control unit 34, respectively.

[0010] It is sent to the data pre-treatment equipment 31, and the projection data from the two-dimensional data collector 12 is at the data pretreatment section 311 first. After general pretreatment of Log conversion (logarithmic transformation) etc. is performed, the after [pretreatment] two-dimensional projection data storage section 312 memorizes. The slanting cross-section approximation projection data origination section 313 creates approximation projection data required to reconfigure the image about a slanting cross section using the projection data after pretreatment. The image re-component 32 reconfigures an image (slanting cross-section image) from the approximation projection data created in the slanting cross-section approximation projection data origination section 313. The so-called half reconstruction approach which can reconfigure an image from the projection data for 180 degrees is adopted as this reconstruction processing. This tomogram data is sent and displayed on an image display device 37 through the main control section 36, and is sent to the image data storage 35, and is memorized. The main control section 36 controls the high-voltage control unit 5, the stand control unit 33, and the berth control unit 34, and performs helical scan.

[0011] Next, an operation of this example is explained. In addition, the moving coordinate of explanation which moves with Analyte P is specified for convenience. In this moving coordinate, by helical scan, the X line source 10 will move a spiral orbit, as shown in drawing 3 (a). In an actual motion, while the X line source 10 and the two-dimensional-array detector 11 carry out continuation rotation, Analyte P moves to an one direction on a berth 2. Here, the jargon treated by the following explanation is defined.

- Actual existence projection data; projection data on the X-ray pass (it is called a virtual path) which is needed in order to reconfigure the image of the projection data and the virtual projection data; reconstruction side of the actual existence actually collected with each detector of the two-dimensional-array detector 11 (here, it defines as a slanting cross section) and which is included ideal, i.e., the reconstruction side concerned. In helical scan, such virtual projection data does not exist really except for some exceptions.

- Approximation projection data; projection data on the X-ray pass in X-ray beam FX most approximated to a virtual path (it is called approximation pass). In addition, this approximation projection data may not exist really by existing really as actual existence projection data. When it does not exist really, it creates with interpolation (distance interpolation) from the actual existence projection data near approximation pass. Approximation projection data is created by every [of the X-ray from the X line source 10 / one / every] radiation direction (a definition is given as whenever [fan interior angle]) about angle of rotation of each of the X line source 10.

[0012] In addition, two or more X-ray pass required for reconstruction cannot define the flat surface of one sheet in helical scan. One of the descriptions of this example sets up the slanting cross section (reconstruction side) which inclines to the Z-axis to the X-ray pass group for half-rotation of the X line source 10, and it is to reconfigure an image using the projection data for this half-rotation (refer to [drawing 3 \(b\)](#)). Thereby, there are few gaps with the curve side and reconstruction side which are drawn by the X-ray pass group for half-rotation, and they can reconfigure an image with little artifact. Furthermore, the description of this example is setting up the slanting cross section where the artifact's makes min the min of gaps, i.e., the above-mentioned amount, to the X-ray pass group for half-rotation, and setting approximation pass. Approximation pass is specified by Z location angle of rotation of the X line source 10, and whenever [fan interior angle].

[0013] The volume data of a three dimension are obtained by repeating reconstruction processing, shifting a slanting cross section little by little in accordance with the spiral orbit of the X line source 10. Spatial resolving power changes according to the migration pitch of this slanting cross section. For example, change of the slanting cross section which it shifted 90 degrees at a time to [drawing 4](#) is shown. According to this approach, a minute (it changes according to a migration pitch) of an image can be reconfigured, for example by one rotation several times of the helical CT of the single slice put in practical use until now or a dual slice.

[0014] It explains below at a detail.

- Although the slanting cross section mentioned above what is specified in approximation by the X-ray pass group which moves while 180 degrees of X line sources 10 rotate about a setup of the virtual flat surface (slanting cross section) which should be reconfigured, it is necessary to specify the virtual flat surface used as the min of the above-mentioned amount of gaps approximated most. The angle of rotation of the X line source 10 and the axis of ordinate are expressed [the spiral orbit of the X line source 10 (source)] for the axis of abscissa as a Z coordinate to [drawing 6](#). The spiral orbit of the X line source 10 is shown on this graph by the primary straight line fsource passing through a zero. On the other hand, a virtual flat surface is the sign curve fplane on this graph. It is shown by carrying out. Here, 180 degree+ fan include-angle 2A, a part for i.e., $90\text{degree}+A$, is given as a view required for half reconstruction focusing on 0 degree. fsource and fplane It will be easily understood that the amount of gaps of a virtual flat surface and the curve side drawn by the X-ray pass group for half-rotation of the spiral orbit of the X line source 10 is small, so that the integral of a difference is small.

[0015] For example, if fan include-angle $2A=50$ degree, it will become $90\text{ degree}+A=115$ degree, but when the ratio of the tilt angle (a graph top is equivalent to the inclination in 0 times of the sign curve fplane) of a virtual flat surface and the inclination of fsource according to the relative-displacement rate of the berth 2 to rotation of the X line source 10 at the time of helical scan is 1.095 at this time, the difference d1 and d2 of both functions is mostly in agreement. That is, the maximum $(|d1-d2|)$ of the absolute value of the difference of both functions is able to specify few optimal virtual flat surfaces of the artifact most by setting up a virtual flat surface so that it may become min. Thus, the approach of setting up a virtual flat surface so that the root mean square of the difference of both functions other than the approach based on the maximum of the absolute value of the difference of both functions may serve as min may be adopted. Of course, it is not limited to such

two approaches.

[0016] - The virtual path contained in a virtual flat surface is rare, therefore virtual projection data hardly exists as actual existence projection data so that I may be understood with reference to drawing 6 about a setup of approximation pass. Therefore, the approximation pass nearest to the virtual path in a flabellate form X-ray beam with fixed thickness is set. Here, when 0 degree is considered whenever [fan interior angle], the pass on the virtual flat surface which passes along the core (it is the same as the center of rotation of the X line source 10) of FOV (Field of View) like drawing 7 is a virtual path. On the other hand, approximation pass is given as pass which passes along a FOV core from the X line source 10. Let the actual existence projection data which passes along this approximation pass be approximation projection data about 0 degree whenever [fan interior angle]. If actual existence projection data existence is not recognized through this approximation pass, approximation projection data is created with interpolation from two actual existence projection data of the channels A and B nearest to the intersection of the approximation pass and a detector side concerned. A thick wire shows notionally change of the intersection group of the detection side of approximation pass to change of angle of rotation to drawing 5. Two kinds of examples are offered about the setting approach of approximation pass.

[0017] (1) The setting approach of the 1st approximation pass (refer to drawing 8 (a))

By this approach, when it sees about an certain angle of rotation of the X line source 10, the intersection to the detection side top of approximation pass will be drawn "in a straight line" with change which is whenever [fan interior angle]. As mentioned above, 0-degree approximation pass is set whenever [fan interior angle] so that a virtual flat surface may be intersected focusing on FOV. An approximation pass group is set up so that the slightly flat ellipse of the virtual flat surface where the intersection of the approximation pass of whenever [other fan interior angle] and a virtual flat surface made the radius from the X line source 10 to the FOV core the core [the X line source 10] may be drawn. It is mentioned that whenever [of actual count / complicated] is small as for the advantage of this approach. All approximation pass required to reconfigure the tomogram for one sheet by this approach to drawing 9 is shown. In addition, the angle of rotation zeta of the X line source 10 expresses with drawing 9 the core of half-rotation that not an include angle but the X line source 10 uses for reconstruction absolutely, as 0 degree, and the Z location rho makes a zero the center position of the successive range where a berth 2 moves while the X line source 10 half-rotates. It expresses with the distance (mm) from a zero, and is used widely and shown to change of migration of angle of rotation of the X line source 10, and Z location of a detector. By drawing 9, while the X line source 10 half-rotates, it is indicated that a berth 2 moves 40mm. The angle of rotation zeta of the X line source 10 of the view of drawing 9 is 0 degree, the Z location rho of approximation pass in case alpha is 0 degree whenever [fan interior angle] is projection data of 0, and, probably, this usually exists really. Of course, if the actual existence pass of this Z location rho does not exist really, approximation projection data is created by interpolation from the actual existence projection data on two pass nearest to the approximation pass concerned.

[0018] (2) The setting approach of the 2nd approximation pass (refer to drawing 8 (b)).

This approach sets approximation pass so that a virtual flat surface may be crossed at the core of approximation pass. The intersection of such an approximation pass and a virtual flat surface draws few ellipses which the cylinder which extended the periphery on XY side which makes a diameter the X line source 10 and distance based on FOV(s) to Z shaft orientations, and the slanting cross section which is a virtual flat surface intersect. Of course, if the actual existence projection data of this approximation pass does not exist, as mentioned above, it creates with interpolation.

[0019] As mentioned above, it is not restrained by a setup of approximation pass, and two examples which could otherwise consider the modification and were raised here although two examples of creation of approximation projection data were given when put in another way. In addition, about interpolation, for every combination of angle of rotation and whenever [fan interior angle], it is made unnecessary [the count process of a interpolation multiplier] in creation of approximation projection data to ask for a interpolation multiplier beforehand, and it can be said from a viewpoint of mitigation of computational complexity that it is effective. Furthermore, a setup of a virtual flat surface and approximation pass can take, and an employment top can be altogether woven into the above-mentioned interpolation multiplier also about the direction.

[0020] Next, an example is given and explained. Here, the distance from 600mm and the X line source 10 to the two-dimensional-array detector 11 is assumed to be 1.1m, and a fan include angle is assumed to be 50 degrees for the radius of gyration of the X line source 10. At this time, FOV (reconstruction field) is $600 \times \sin(50 \text{ degrees}/2)$. It is set to about 250mm. moreover, if the two-dimensional-array detector 11 is put in another way nine channels to a Z direction (the slice direction), a one dimensional array detector will assume that it is 9 successive-installation ***** to a Z direction. Moreover, it is assumed that the one dimensional array detector is arranged with the row pitch (a row pitch is set to 2.57mm at this time) which is equivalent to 1.4mm spacing at a FOV core. Moreover, while the X line source 10 rotates one time, it is assumed that the movement magnitude of a berth 2 is 15mm. A gap of approximation pass within FOV at this time and the Z direction of a virtual flat surface can also estimate the plus direction and minus direction at about 0.41mm by count. Ejection of the approximation projection data from the storage section 312 is performed according to drawing 9. Linearity distance interpolation may be used for interpolation processing, and it is risen. Any of the interpolation using a cosine function are sufficient. The need range of the data on the two-dimensional-array detector 11 can be estimated at double sign 10.18mm, and enters into existence range $2.57\text{mm} \times 4 = 10.28\text{mm}$ of a detector 11. Activation slice thickness will be more thickly set to about 2mm to width of face of 1.4mm of the channel based on FOV(s), in order that interpolation processing may enter at the time of approximation projection data origination. At this time, error 0.41mm of a previous Z direction is a small error suitably, and is understood by not coming to generate the big artifact in image quality.

[0021] Next, image reconstruction is explained. An image will be obtained if two-dimensional half image reconstruction is performed from approximation projection data. As actual processing, it is good only by performing two-dimensional half reconstruction as usual to the approximation projection data obtained as mentioned above. Although an opposed beam will be obtained a little if the data for a 180 degree + fan include angle are used at this time, averaging of these both may be carried out and one side may be chosen. Of course, data are acquired in a little larger include-angle range, and it is good as for a method of "being weighting ***** smoothly" in an opposed beam.

[0022] By the way, that the system of coordinates of reconstruction should just reconfigure about X perpendicular to a Z direction, and a Y-axis, although a reconstruction side has an inclination slightly by this, it is obtained as an image which looked at this from the Z direction. There is no need of restarting the two-dimensional coordinate within a virtual flat surface. Since the reconstruction side which continues as it may say that data from the first are collected by X and Y coordinate and being mentioned above is not parallel, it is thought that the direction with X and Y coordinate is easy to treat as three-dimension data on the contrary.

[0023] The above explanation has described collection of volume data focusing on acquisition of a single slice. What is necessary is just to shift a little half-rotation range required to reconfigure the image of one sheet, in order to obtain volume data (refer to drawing 3 (a)). For example, what is necessary is to shift the half-rotation range in the pitch of $360 \text{ degrees} / 8 = 45 \text{ degrees}$, and just to set up a virtual flat surface between 1 rotations of the X line source 10, in wanting the image of eight sheets.

[0024] Now, the image obtained is not parallel even if it creates an image one by one in a pitch 45 degrees in accordance with the spiral orbit of the X line source 10. For this reason, although spatial resolving power changes in the XY direction, this is considered reflecting the spatial asymmetry of the spiral orbit of the X line source 10 from the first, and it can be said in that semantics that it is very natural.

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[0027] Drawing 10 is a flow chart which shows the flow of a series of processings from data collection to reconstruction, and shows a certain slanting cross section to drawing 11 . When setting the inclination of h [mm] and a virtual flat surface to κ for the berth movement magnitude per rotation, The slanting cross section P (ζ) centering on the location which carried out zetaradian rotation, i.e., ($\zeta/2\pi$), the location of [mm], is $P(\zeta) = \{(x, y, z) \mid z = (\zeta/2\pi) + [(x, y)](-\sin \zeta, \cos \zeta) \times \tan \kappa\}$.

It is come out and given. However, "-" expresses an inner product.

[0028] Here, if it is the angle of rotation β of the X line source 10, whenever [fan interior angle / α], and the location ρ of a Z direction, this approximation projection data shall be expressed as $R(\beta, \alpha, \rho)$. In fact, since projection data is obtained discretely, it is expressed as $R(l(\beta), m(\alpha), n(\rho))$. In addition, it is $m = -M/2 - +M/2$, and $n = -N/2 - +L/2$.

[0029] Since the X line source 10 carries out number rotation by helical scan, β becomes wide range. This range I is set to $I = LL1 - LL2$. Moreover, range corresponding to $-(\pi/2 + A) - (\pi/2 + A)$ at the real include angle which is the range required for half reconstruction - It is described as $L/2 - +L/2$.

[0030] Now, the X line source 10 will consider reconstruction of the slanting cross section in the location which only ζ rotated. The Z location ρ on the detector of the approximation pass of all approximation projection data required in order to reconfigure the reconstruction image H of this slanting cross section (ζ) is given as $\rho(\beta, \alpha)$ as a function of β and α .

[0031] $H(\zeta)$ is obtained as follows.

(STEP1) Approximation projection data $R(\zeta, \beta, \alpha)$ of a slanting cross section is $R(\zeta, \beta, \alpha) = R(\zeta + \beta, \alpha, \rho(\beta, \alpha))$.

It is come out and created. At this time, it is $\zeta + \beta = (I(\zeta)) - (\beta)$.

$\alpha = (m(\zeta)) - (\alpha)$

(n-1) When $-(\rho) \leq \rho(\beta, \alpha) < n - (\rho)$, it is $R(I(\zeta) - (\beta), m(\zeta) - (\alpha), \alpha - (n-1)(\rho))$ in fact.

$R(I(\zeta) - (\beta), m(\zeta) - (\alpha), \alpha - (n-1)(\rho))$

Approximation projection data is created by interpolation processing from the actual existence projection data of two **.

(STEP2) Image $H(\zeta)$ is reconfigured with a predetermined half reconstruction algorithm in the direction which only ζ rotated using approximation projection data $R(\zeta, \beta, \alpha)$.

[0032] In addition, as soon as reconstruction of an image required one by one during activation of helical scan is completed, one by one, as long as the storage capacity of the storage section 312 is large enough, it may be made to eliminate approximation projection data R , and to perform reconstruction processing after helical scan termination.

[0033] This invention cannot be limited to the example mentioned above, but can deform variously, and can be carried out. Sequential explanation of the modification is given below.

(1) Resolution can be raised by using together concomitant use this invention of a shift device, and a shift device. For example, the juniper the radius of gyration of the X line source 10 "was shifted" so that 600mm of an above-mentioned example might be set to two thirds of 400mm. This is interlocked with and slice thickness also makes 10mm of 2/3 also set movement magnitude of the berth per X line source 101 rotation to two thirds from 15mm in this method. Although it is not

necessary to make it not necessarily interlock, it is most efficient for the whole slice direction
***** target to raise resolution.

[0034] (2) It was what is referred to as that 180-degree rotation part extent of the spiral orbit of the X line source 10 will extract and bring together the projection data near this helical slanting cross section in one flat surface paying attention to being contained in approximation, and the fundamental idea of use this invention of a partial angle reconstruction method will perform the usual two-dimensional half reconstruction. If the ** office of the spiral orbit is carried out to a part, the part approximation will become good. A partial angle reconstruction method is used together as a modification of this method. Since location-approximation of the spiral orbit of the X line source 10 and a virtual flat surface will become very good if this method is used, an image can be obtained even if the virtual flat surface has whenever [tilt-angle] further. Therefore, "the fan include angle of the slice direction" can be enlarged and the effectiveness of photography improves further.

[0035] (3) the correspondence to inverse rotation (berth hard flow migration) -- in actual equipment, the migration direction of a berth may be used in both directions of the direction inserted in CT stand, and the direction to pull out. Moreover, the hand of cut of the X line source 10 itself can consider two kinds of inverse rotation ***** in this case -- since the relative screw motion of the X line source 10 over analyte is symmetrical with a mirror image -- the above-mentioned data processing (creation of approximation projection data, coordinate of a back projection operation, etc.) -- all are considered as the mirror image symmetry.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The block diagram of CT concerning this example.

[Drawing 2] The block diagram of the data pre-treatment equipment of drawing 1.

[Drawing 3] Drawing showing the spiral orbit of X line source in helical scan.

[Drawing 4] Drawing showing change of the slanting cross section which it shifted 90 degrees at a time.

[Drawing 5] The conceptual diagram showing change of the intersection group of the detection side of approximation pass to change of angle of rotation.

[Drawing 6] Drawing showing the spiral orbit of X line source, and the equipment of a virtual flat surface.

[Drawing 7] Drawing showing a 0-degree virtual path and approximation pass whenever [fan interior angle].

[Drawing 8] The explanatory view of the setting approach of approximation pass.

[Drawing 9] Drawing showing Z location of all approximation pass required to reconfigure the tomogram for one sheet.

[Drawing 10] The flow chart which shows the flow of a series of processings from data collection to reconstruction.

[Drawing 11] Drawing showing the slanting cross section corresponding to drawing 10.

[Description of Notations]

1 -- Stand 2 [4 / 10 / 3 / 31 / 33 / 35 / 37 -- Image display device. / -- Image data storage 36 -- Main control unit / -- A stand control unit, 34 -- Berth control unit / -- A data pre-treatment equipment, 32 -- Image re-component / -- A stand driving gear, 20 -- Berth driving gear / -- X line source 11 -- Two-dimensional-array detector / -- A high-voltage transformer assembly 5 -- High-voltage control unit] -- A berth, 3 -- Console

[Translation done.]